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(54) HYDROCARBON CRACKING PLANT

(71) We, COMPRIMO BV., of James Wattstraat 79, Amsterdam, Holland, A Dutch Body Corporation, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:–

The present invention relates to a hydrocarbon cracking or reforming plant and process.

It is known that, in a thermal or catalytic hydrocarbon cracking or reforming plant having a cracking or reforming furnace, the burners of this furnace must be fired by a high grade fuel (such as naptha, kerosene, diesel oil or natural gas) in order to prevent corrosion of the extremely hot tubes in which the hydrocarbon is cracked or reformed. Also, it is necessary that the hydrocarbon which is to be cracked or reformed should be of high grade, and this will be more especially required when the gaseous product resulting from the cracking or reforming is to be used for further synthesis (i.e. as a synthesis gas). Therefore, as a rule, high grade fuel is used both for the hydrocarbon feed and for the burner fuel feed.

It is also known that such a synthesis gas can be manufactured by partial oxidation of hydrocarbons with pure oxygen or with gases which are rich in oxygen. This, however, necessitates the use of a costly air separation unit for the provision of the oxygen or the oxygen-rich gas. Furthermore, it is known to use a combination of hydrocarbon cracking or reforming and combustion of hydrocarbons without using an air separation unit, but with a gas turbine unit in order to recover the enrgy in the gases.

However, all of these processes must use high grade fuel both as feedstock and as the burner feed. The prices of such high grade fuels are rather high and are steadily increasing. Therefore a cheaper fuel is required.

It is known to produce a high grade combustible gas from sulphur-containing fuels by partial combustion with an oxygen-rich gas and removal of the hydrogen sulphide generated by that partial combustion. However, this process, also, necessitates a costly air separation unit. Conversion of an existing plant based on the cracking or reforming of hydrocarbons to the process of partial oxidation of hydrocarbons requires a completely new plant and thus involves high investment, which is especially undesirable when the existing facilities are still in good working order.

We have now found that particularly advantageous use can be made of the low cost of heavy residual oil if part of the high grade fuel is maintained and at least the burner feed fuel is replaced by a combustible gas produced from heavy residual oil. This enables existing facilities to be left completely intact.

Thus, the present invention provides thermal or catalytic hydrocarbon cracking or reforming plant having a cracking or reforming furnace (generally of a type hitherto fired by a high grade fuel) and comprising: an oil gasification unit for gasification of a heavy residual oil by partial oxidation with oxygen; a gas purification unit for removal of H_2S from the resulting gas, optionally with conversion of the H_2S into sulphur; a gas turbine unit for generation of electricity from part of the purified gas leaving the gas purification unit (useful for energising units as needed); a feed duct for passing part of the purified gas from the gas purification unit to a fuel inlet of a burner of the cracking or reforming furnace; and a feed duct for passing oxygen-rich exhaust gas from the gas turbine unit to an air inlet of the burner of the cracking or reforming furnace.

The present invention further provides a process for the cracking or reforming of a hydrocarbon feedstock in which the hyd-

rocarbon feedstock is cracked or reformed in a furnace fired by the gases produced by: partial oxidation of a heavy residual oil with oxygen to produce a gas; removing H_2S and preferably also COS from said gas, the H_2S then optionally being converted into sulphur; dividing the resulting gas into at least two streams; passing one of said streams to a gas turbine to generate electricity and to produce an oxygen-rich exhaust gas; and passing said oxygen-rich exhaust gas and another stream of said resulting gas to an air inlet and a fuel inlet respectively of a burner of said furnace to fire said furnace.

As is common practice in this art, the inlets for the combustion-supporting gas are referred to herein as 'air-inlets', althoughv-whe gas used to support combustion need not, of course, have the composition of atmospheric air.

The gas rich in oxygen and used for the gasification of the heavy residual oil may be generated in an air separation unit for the production of a gas rich in oxygen and of a gas rich in nitrogen. In a preferred embodiment of the invention the plant also comprises a waste-heat boiler, which is fed with part of the oxygen-rich exhaust gas from the gas turbine unit, to produce steam.

A still further embodiment of the invention provides a cracking or reforming plant as described above, wherein part of the purified gas leaving the purification unit (after removal of H_2S) is fed to a further desulphurization unit, the exhaust of which is connected to the synthesis gas of H_2 + CO derived from the reforming furnace or furnaces.

Efficiency can be achieved by the process of the invention because: (a) gas produced by an oil gasification unit is produced at a pressure suitable for feeding to burners of a furnace or furnaces or to a combustion chamber of a gas turbine; (b) a gas turbine yields an exhaust gas which is sufficiently rich in oxygen to function as an oxygen source for burners of a furnace or furnaces; and (c) sensible heat in the exhaust gas of the gas turbine may be removed.

It is possible to proide the oil gasification unit with oxygen by introduction of normal air; this is particularly applicable in those cases in which the construction of the cracking or reforming furnace is adapted to the low calorific value of the gas produced (for instance 1100 kcal/Nm^3). In that case the surface area of the heat exchanging surfaces should be adapted to this low calorific value.

The air is preferably compressed and the energy necessary for operation of the compressor may be delivered by the gas turbine. Otherwise the plant may additionally comprise an air separation unit, which can also be energized by the gas turbine.

Since nitrogen is available in the plant of the invention when an air separation unit is used (as a result of the production of an oxygen-rich gas from air) the application of the plant for production of a feed gas for an ammonia synthesis plant has distinct advantages. Further illustration of the invention, therefore, relates to ammonia synthesis plants. However, the plant and process of the invention can also be used in other plants using a synthesis gas, such as in a methanol synthesis plant.

The invention is further illustrated with reference to the accompanying drawings, in which:–

Figure 1 is a flow sheet showing a first embodiment of the invention employed in an ammonia plant, in which the fuel gas for the burners of the cracking or reforming furnace is supplied by heavy oil gasification;

Figure 2 is a flow sheet showing a modification of the plant shown in Figure 1, in which part of the synthesis gas is also derived from the heavy oil gasification;

Figure 3 is a flow sheet showing a further modification of the plant of Figure 1, in which part of the compressed air produced in the gas turbine is used as a diluent for the oxygen-rich gas issuing from the air separation unit; and

Figure 4 is a flow sheet showing a second embodiment of the invention, in which the air separation unit is replaced by a compressor.

Figure 1 is a flow sheet showing an ammonia synthesis plant using the invention in its simplest form. Conventionally, the burners 2 of a primary reforming furnace 1 must be fired by a high-quality fuel, such as naphtha, kerosene, diesel oil or natural gas, in order to prevent corrosion of the extremely hot tubes in which the hydrocarbon is cracked or reformed. According to the invention this fuel is replaced by a fuel of lesser quality, which can be obtained at a lower price. For this purpose an oil gasification unit 3 (which is based on well-known principles for this type of fuel conversio) is used. In the unit 3, gasification of heavy residual oil takes place as a result of partial combustion of this oil, preferably using oxygen of about 95% purity, which is obtained from an air separation unit 4. The crude fuel gas thus obtained is cooled in the gasification unit and produces a certain amount of steam from boiler feedwater, this steam leaves the unit at 5 for use in various other parts of the plant. The crude gas 6 then enters unit 7, in which the H_2S and part of the COS, which are present in thė gas, are removed in a known manner. Several processes are available for this removal in practice for example, in the regenerator unit 7, steam may be introduced at 11 to drive the H_2S out of the solution, this H_2S passes along duct 8 to a Claus process unit 9, in

which it is transformed into pure liquid sulphur.

The desulphurized fuel gas 10 has a calorific value of about 3000 kcal/Nm³ and consists mainly of hydrogen and carbon monoxide. It may be used for several purposes. In the invention it is used as a fuel gas (fed along duct 12) for furnace burners as a fuel gas for a gas turbine 15 (fed along duct 14) and optionally as a fuel gas for boilers (fed along duct 13). The gas turbine 15 produces electricty 16, which is sufficient to supply the power shown at 17 for the air separation unit 4 and for the gasification unit 3, the rengenerator unit 7 and the Claus kiln 9 and possibly also for the ammonia synthesis plant 19.

The exhaust gas 20 from the gas turbine 15 is divided into two streams; the main stream 21 is used as an oxygen carrier for burning the fuel gas from duct 12 in the burners 2. A minor stream 22 is fed to a waste-heat boiler 23 in which steam 24 is produced, this steam then being ed into the steam distribution system.

If desired, the electricity 16 generated in the generator of gas turbine 15 may beincreased, so that a certain amount of electricity 29 can be used for other purposes or can be sold.

A variant in which the overall economy is increased is shown in Figure 2. The units and their functioning are as shown with reference to Figure 1, but with the modification that the production of fuel gas from oil gasification is increased so that certain amount of fuel gas 25 can be mixed with the gas stream to the ammonia synthesis plant 19 after further desulphurization in unit 26 and after heating in a heat exchanger 27. This allows a certain reduction of the hydrocarbon feed 28, which increases the overall economy.

In a still further variant, shown in Figure 3, the gasification of oil in unit 3 is performed by means of partial oxidation with enriched air instead of by oxygen of about 95% purity. The enriched air stream 33 may have, in general, an oxygen content of 50–60% and may be obtained by: (a) using the system shown in Figure 3, in which air 30 is bled from the compressor of the gas turbine 15 and its pressure is increased to a suitable level by the booster compressor 31, aftjr which it is mixed with an oxygen stream 32 from the air separation unit 4, resulting in an enriched air stream 33 for feed to the oil gasification unit 3, or (b) using an air separation system 4 based on air separation by molecular sieves, which have the property of delivery oxygen at relatively low cost, but also of a low purity (in general, the oxygen content of the enriched air obtained in this manner is 50–70%).

In the variant shown in Figure 4, the oxygen for the oil gasification unit 3 is obtained from the ambient air, which is compressed in the compressor 34. This embodiment may only bs used when the cracking or reforming furnace is adapted to use a gas with a low calorific value.

WHAT WE CLAIM IS:–

1. A thermal or catalytic hydrocarbon cracking plant having a cracking or reforming furnace and comprising: an oil gasification unit for gasification of a heavy residual oil by partial oxidation with oxygen; a gas purification unit for removal of H_2S from the resulting gas; a gas turbine unit for generation of electricity from part of the purified gas leaving the gas purification unit; a feed duct for passing part of the purified gas from the gas purification unit to a fuel inlet of a burner of the cracking or reforming furnace; and a feed duct for passing oxygen-rich exhaust gas from the gas turbine unit to an air inlet of the burner of the cracking or reforming furnace.

2. A plant according to claim 1, additionally comprising an air compressor for delivering compressed air to the oil gasification unit to provide oxygen.

3. A plant according to claim 1, additionally comprising an air separation unit for the production of an oxygen-rich gas to be fed to the oil gasification unit.

4. A plant according to any one of claims 1 to 3, additionally comprising a branch line in said feed duct to the air inlets of the burner, with a waste-heat boiler for the production of steam, and a steam discharge line.

5. A plant according to any one of claims 1 to 4, additionally comprising a branch line in said feed duct for purified gas, connected with a desulphurization unit and a heat exchanger, discharging into a feed duct of synthesis gas, derived from a reforming furnace.

6. Aplant according to any one of claims 1 to 5, additionally comprising a feed duct for synthesis gas, derived from the reforming furnace connected with an ammonia synthesis unit.

7. A plant according to claim 1, substantially as hereinbefore described with reference to, and as shown in any one of Figures 1 to 3 of the accompanying drawings.

8. A plant according to claim 1, substantially as hereinbefore described with reference to, and as shown in Figure 4 of the accompanying drawings.

9. A process for cracking or reforming a hydrocarbon feedstock, in which the hydrocarbon feedstock is cracked or reformed in a furnace fired by the gases produced by: partial oxidation of a heavy residual oil with oxygen to produce a gas; removing H_2S from said gas, dividing the resulting gas into at least two streams; passing one of said

streams to a gas turbine to generate electricity and to produce an oxygen-rich exhaust gas; and passing said oxygen-rich exhaust gas and another stream of said resulting as to an air inlet and a fuel inlet respectively of a burner of said furnace to fire said furnace.

10. A process according to claim 9, in which COS is also removed from the gas produced by partial oxidation.

11. A process according to cluim 9 or claim 10, in which said H_2S is subsequently converted to sulphur.

12. A process according to claim 9, substantially as hereinbefore described with reference to any one of Figures 1 to 3 of the accompanying drawings.

13. A process according to claim 9, substantially as hereinbefore described with reference to Figure 4 of the accompanying drawings.

14. A cracked or reformed hydrocarbon when produced by a process according to any one of claims 9 to 13.

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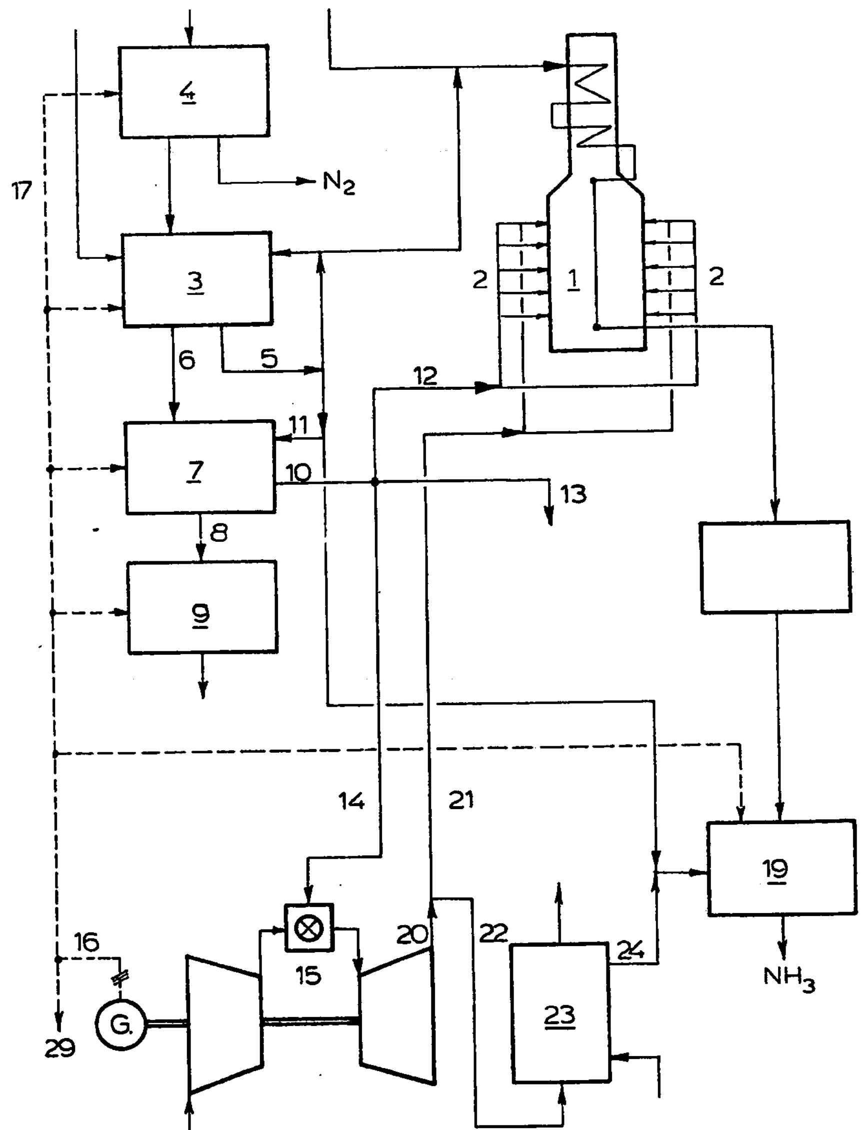

fig.1

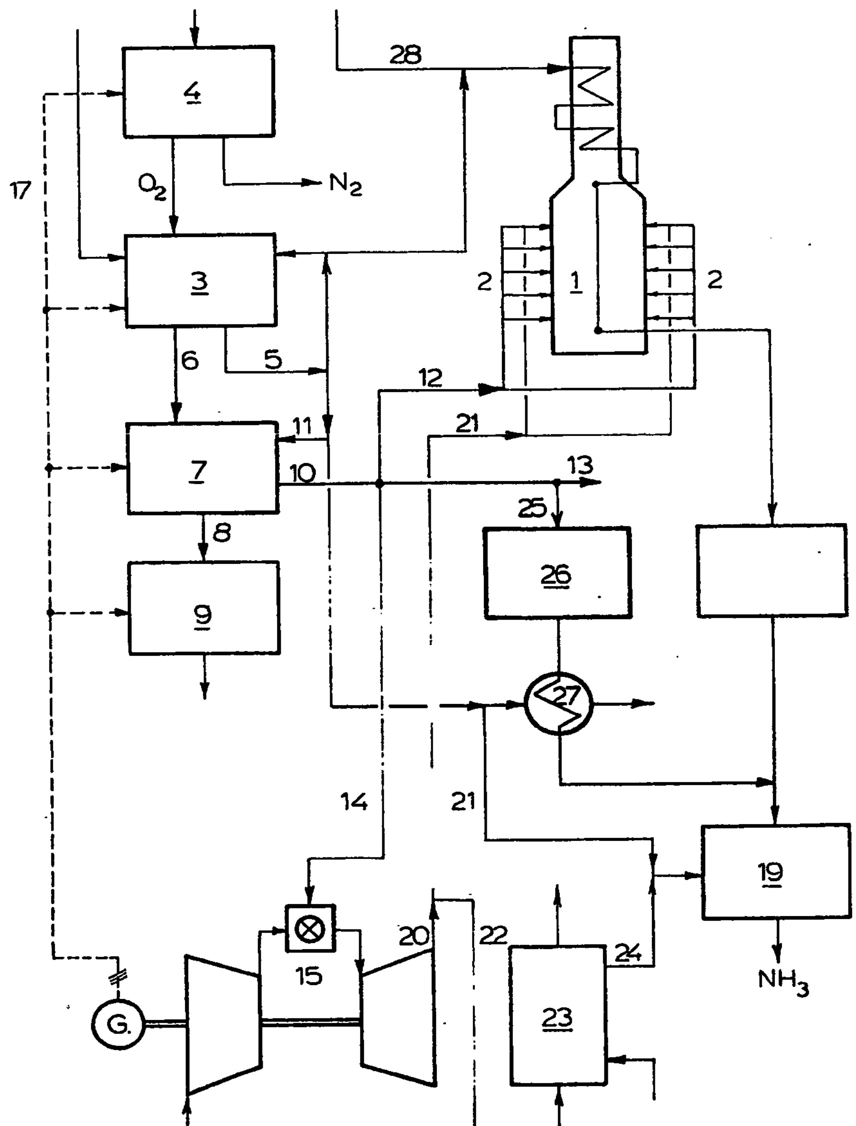
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fig.2

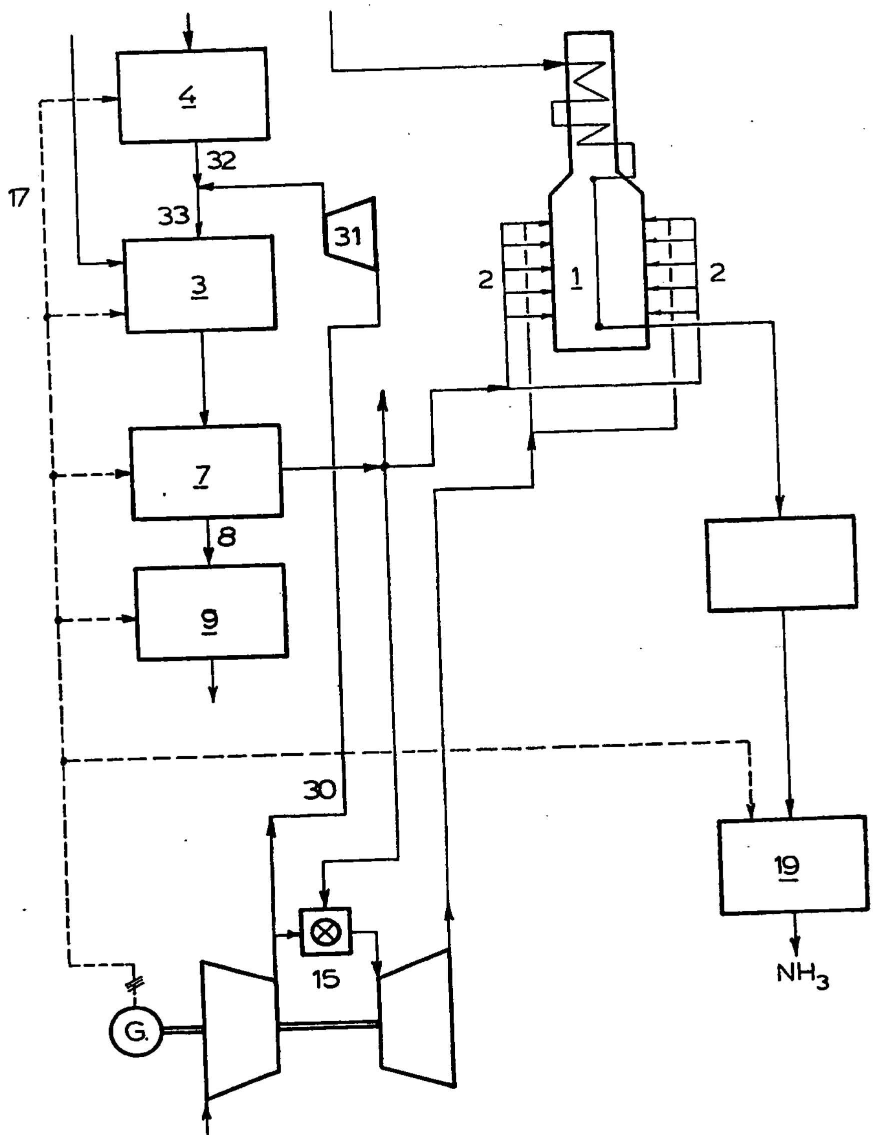

fig.3

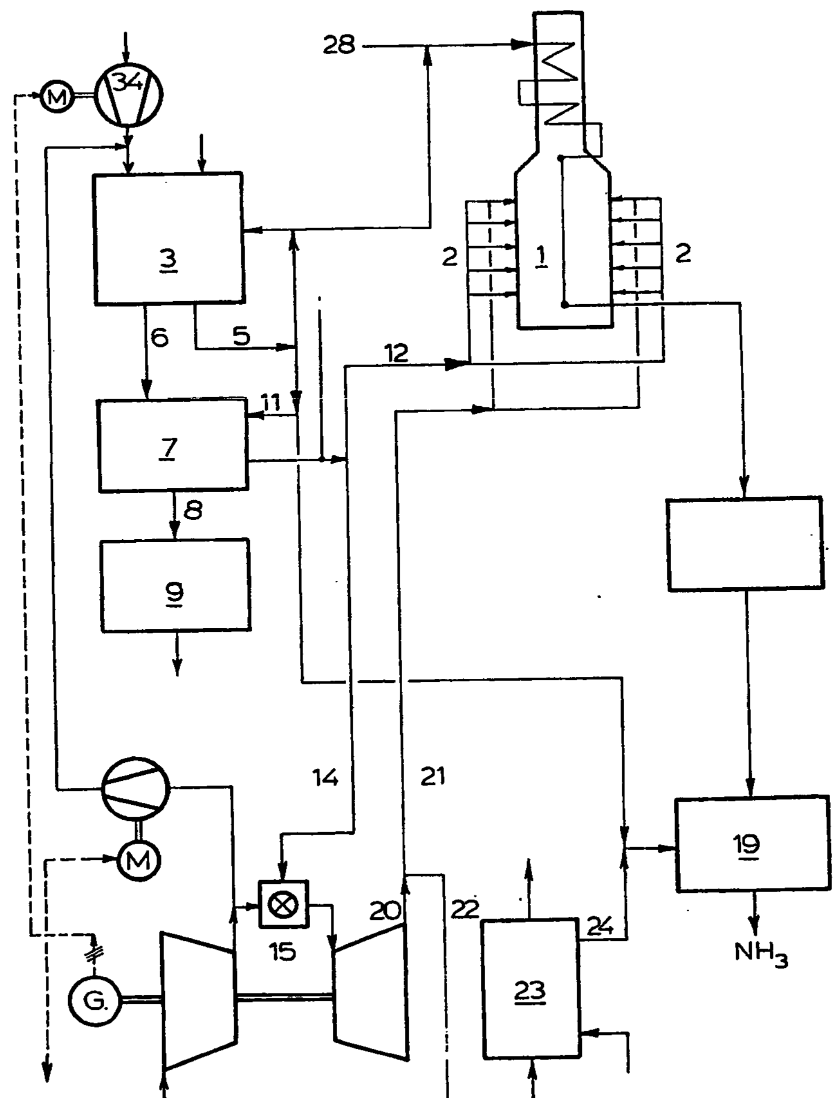

fig.4